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AUTHOR Matthews, Westina
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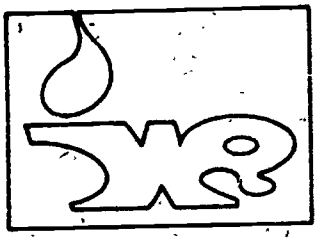
ABSTRACT

A review of 24 representative studies conducted on minorities and mathematics between 1975 and 1982 is presented. A number of variables, categorized by parent, school, and student, are identified as having an influence on minority students' learning of and participation in mathematics. Trends and patterns identified in race-related differences in mathematics performance and mathematics enrollment are discussed. Questions are raised to guide future research, and several prevention and intervention strategies are suggested. (MNS)



Program Report 83-5

Influences on the Learning and Participation of Minorities in Mathematics

by Westina Matthews

January 1983

Wisconsin Center for Education Research
an institute for the study of diversity in schooling

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Westina Matthews

A Report from the
Postdoctoral Fellowship Program

Wisconsin Center for Education Research
University of Wisconsin
Madison, Wisconsin

January 1983

Dr. Matthews is now Staff Associate at the Chicago Community Trust in Chicago, Illinois.

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Wisconsin Center for Education Research

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- diversity as a key issue in relations between individuals and institutions, through studies of school processes
- diversity as a fundamental question in American social thought, through studies of social policy related to education

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Finally, to minority students I leave this thought: Color may not only be beautiful, it can be brilliant; don't be afraid to shine.

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I. INTRODUCTION

Employment opportunities are available in the sciences, but historically such opportunities have been avoided by many minorities (e.g., Blacks, Mexican-Americans, Puerto Ricans, Native Americans). While major efforts have been made to encourage students, across racial groups, to consider science careers, minorities are still underrepresented in occupations which require a background in mathematics (Vetters & Babco, 1981). Because mathematics is a sequential subject and most science positions require a mathematics background, minorities must be encouraged to begin their mathematics education early and to continue at least through high school.

It has been well established that minorities are consistently scoring below the national norms on standardized mathematics tests and are not enrolling in advanced high school mathematics classes (e.g., National Assessment of Educational Progress, 1980; Peng, Fetters & Kolstad, 1981). Although socio-cultural factors or genetic influences have been suggested for this discrepancy, there appears to be little hard evidence to support these speculations. Indeed, there is a paucity of research available specifically on the topic, and oftentimes researchers must draw from other disciplines (e.g., psychology, sociology).

For those studies in which either the learning of or the study of mathematics by minorities is addressed, there are several problems that affect their usefulness or appropriateness. One problem is that most of the studies usually are either unpublished papers or are final reports to funding agencies and, therefore, are inaccessible to the general public.

Another problem is that some of the findings of these studies could be considered serendipitous in that neither the original nor primary objective of the study was to examine minorities. (More often than not, the study was of sex-related differences and race was included as a background variable.) Inadequate reasons are then given to explain any race effects. Although individually these studies may have design or methodological problems, considered collectively, they report consistent patterns.

The purpose of this paper is to develop an understanding of why minorities continue not to participate in or to learn mathematics.[1] This understanding will be based upon a careful review of research conducted on minorities and mathematics since 1975. Trends and patterns that have been identified in race-related differences in mathematics performance and mathematics enrollment will be discussed. Research questions will be raised that might guide future research endeavors, and a few recommendations will be made for prevention and intervention strategies.

II. OVERVIEW OF THE STUDIES

Selection

For this review 24 studies were selected. The year 1975 was chosen as the initial year because it appears to be the beginning of research on minorities and mathematics. This may be because much of the research on women and mathematics was well underway, and questions were beginning to be raised about the participation of minority women in mathematics. Indeed, the titles of the papers and reports reviewed in this paper, indicate that many of the earlier studies (1975-1978) are about minority women in the sciences or about women and minorities. It is after 1978 that there are more research studies solely concentrating on minorities.

The 24 studies selected for review may not be exhaustive but are believed to be representative. It is recognized that there is a very good body of research available on race-related differences in the affective domain (e.g., achievement orientation, self-esteem, locus of control) in which one of the outcomes is mathematics achievement. Those studies have been excluded because they did not meet the major criterion for selection: the major purpose of the study was to understand why minorities are under-represented in mathematics and science.

General Description

The following is a brief summary of the 24 studies. In Table 1, the sample, the date of data collection, and the racial composition of the samples are outlined. Many of the studies discussed in this paper have been written since 1980. With only three exceptions (Anick, Carpenter & Smith, 1981; Jones, Burton, & Davenport, 1982; Kenschaft, 1981), the

TABLE 1

Selected Studies on Minorities and Mathematics

1975 - 1982

Authors & Date	Population (Sample Size)	Date of Collection	Racial Composition of Sample
Anick, Carpenter & Smith, 1981	9-, 13-, and 17-year-olds (70,000)[a]	1977-1978	14% Black 5% Hispanic 80% White 1% Other
Creswell & Houston, 1980	8th and 11th graders in Houston, TX (300)	1979	33% Black 33% Chicano 33% Anglo
Cuevas & Llabre, 1981	4th and 5th graders in 5 schools in Dade County, FL (408)	1980	100% Hispanic
Erlick & Lebold, 1977	10th and 12th graders (8,621)[b]	1975	15% Nonwhite 85% White
Fernandez, Espinosa, & Dornbusch, 1975	8th and 10th graders from 8 San Francisco high schools (770)	1974	27% Black 17% Spanish-surnamed 24% Asian American 24% White
Hall, 1981	female scientists (52)	1980	...minority
Hedges & Majer, 1972	students at 7 University of California campuses (51,622)	1976	....Black ...Chicano ...Asian American
Jackson, 1982	10th and 12th graders (72,000)[c]	1980	...Black ...Hispanic ...White
Jones, Burton & Davenport, 1980	9-, 13-, and 17-year-olds (70,000)[a]	1977-1978	14% Black 5% Hispanic 80% White 1% other
Kenschaft, 1981	women who earned doctorate in pure or applied math (20)	1978-1981	100% Black
Kirk, 1975	11th grade females in San Francisco Bay area (500)	1974	18% Asian American 79% White 3% other

TABLE 1--Continued

Selected Studies on Minorities and Mathematics

1975 - 1982

Authors & Date	Population (Sample Size)	Date of Collection	Racial Composition of Sample
Lantz & Smith, 1981	high school students in San Francisco Bay Area (362)	1979	30% Black 70% White
Malcom, Hall, & Brown, 1976	women scientists (30)	1975	46% Black 17% Mexican American 20% Puerto Rican 17% Native American
Marrett, 1981	high school students (18,437)	1979-1980	44% Black 56% White
Matthews, 1980	high school students in Oakland, CA (630)	1978-1979	50% Black 25% Asian American 25% White
MacCorquodale, 1981	11th graders (900) and 12th graders (1500) in Nogales and Tucson, AZ	1979-1980	80% Mexican American 20% Anglo
McNamee, Katz, & Bowman, 1981	4- and 5-year-old low income children in Chicago, ILL (...)[e]	1980-1981	100% Black
Nelson, 1978	5th graders (67) and 11th graders (82) in New Orleans	1977	100% Black
Rancifer, 1978	high school seniors in Arkansas (683)		33% Black 67% White
Sells, 1978	high school students in a west coast district (2500)	1979	40% Black 48% White 2% Hispanic 8% Asian American
Skypek, Lee & Cox, 1976	9th and 12th graders (2,626)[d]	1960-1974	100% Black
Thomas, 1981	high school seniors (16,683)[f]	1972-1976	100% Black

TABLE 1--Continued

Selected Studies on Minorities and Mathematics

1975 - 1982

Authors & Date	Population (Sample Size)	Date of Collection	Racial Composition of Sample
Treisman, 1982	freshmen and sophomores college students at University of California-Berkeley (643)	1973-1981	67% Black 33% Chicano
Tsang, 1976	7th and 8th graders in 3 CA cities (323)	1975	100% Chinese

[a]National Assessment of Educational Progress (1980)

[b]The Purdue Opinion Poll 101 (Erlich & LeBold, 1975)

[c]High School and Beyond (Peng, Fetters & Kolstad, 1981)

[d]Project Talent (American Institutes for Research, 1972)

[e]...exact number or percentages not reported

[f]National Longitudinal Study (Fetters, 1972)

studies are not easily accessible to the general public. Nearly 50% of the authors were minorities, and most of those were black. Six of the studies used national samples, and eight of the studies used samples located in California. In five of the California studies, Berkeley High School was one of the sites. The majority of the studies used cross-sectional data; in only a few cases were the data collected over more than one year (Kenschaft, 1981; Skypek, Lee & Cox, 1976; Thomas, 1981; and Treisman, 1982). Over 75% of the studies used blacks as the comparison racial group, and in 50% of the studies Hispanics were used.

There appeared to be little consistency in either the gross classifications of the minority populations studied or the instruments selected. For the majority of the studies in which there were multiracial comparisons, Chinese, Vietnamese, Japanese, and Pacific Islanders were often lumped together to form the group Asian Americans. The Spanish-surnamed--Puerto Ricans, Cubans, Mexican-Americans--were lumped inconsistently together to form the group Hispanics. Other was used to classify the Alaskans and Native-Americans.

There was little consistency in the kind of instruments for the analyses. Except for those few studies in which national assessment data were used, either a standard test, a self-made questionnaire, or an interview protocol was used. It is suspected that the researchers used the standardized test which was administered by the school. The Fennema-Sherman attitude scales (Fennema & Sherman, 1977) were used in two studies (Nelson, 1978; Rancifer, 1978). Otherwise, researchers developed their own questionnaires to measure mathematics attitudes and anxieties. Because of the different emphases, it is difficult to compare the findings from these questionnaires across studies.

III. INFLUENCES ON PARTICIPATION AND PERFORMANCE

The two outcomes that have been consistently studied are mathematics participation and performance. Both the desire to take more mathematics, aspirations, and the completion of the course, persistence, have been researched as participation variables. Mathematics performance included measures of achievement, performance at one time, and of progress, change over time.

Three clusters of variables have been identified as having an influence on the minority student's performance or participation: parent, student, and school. Ascribed characteristics (race, sex, age) of parents were studied as well as cognitive (past and present education and occupation), affective (expectations, aspirations, attitudes) and cultural (communication style, primary language spoken at home) variables. Within the student cluster, variables studied were ascribed characteristics, cognitive (past and present enrollment and performance), affective (aspirations, expectations, self-concept), and cultural (cognitive learning style, language proficiency). The school variables were climate, organization, resources, racial composition, and school personnel.

These clusters of variables seemed to have varying effects on the mathematics participation and performance of minorities. How these variables were related to one another and how they might operate differently for the various racial groups were two of the major research questions that were posed in the studies. After critically reviewing these studies, it may be that we can find answers to these questions. The following is a discussion of these influences. Because the two outcomes--performance and

participation--are so closely intertwined, the review of the studies is organized by the influence of the variables on both outcomes. In Table 2, the outcomes and the influences investigated in each of the 24 studies are identified. Although discussed in the text, ascribed characteristics for both parents and students are not described in the table.

Parent Influence

It may help to think of the parent influence as that which a student brings to school that might affect the student's experiences within the school, what Bloom (1964) called entry characteristics. There were at least six of these variables that were found to have an influence on students' mathematics participation or performance.

Cognitive. There is some evidence to suggest that mothers' education and occupation may be a better predictor of future students' success (e.g., performance) than fathers' influence. There is little empirical evidence to support this, however, because most of the findings reported for parental influence are perceptions of the students rather than actual observed or parent reported influence.

Affective. It is only from those studies of minority women scientists (Hall, 1981; Kenschaft, 1981; Malcom, Hall & Brown, 1976) that we find mothers' attitudes about mathematics or attitudes about their childrens' ability to perform to be reported to have an influence. One should be cautious in concluding that mothers have a larger influence than fathers. Due to the growing phenomenon of single head-of-household parents (usually the mother) of black and Hispanic students, reported mothers' influence may be more a reflection of family patterns than direct mother intervention.

TABLE 2

Description of Selected Studies on Minorities and Mathematics by Influences and Outcomes

Author and Date	Influences													Outcomes			
	Parent			Student			School							Performance		Participation	
	cognitive	affective	cultural	cognitive	affective	cultural	climate	organization	resources	racial composition	personnel			achievement	progress	aspirations	persistence
Anick, Carpenter & Smith, 1981	x			x	x									x			x
Creswell & Houston, 1980					x									x			
Cuevas & Llabre, 1981			x	x		x								x			
Erlick & LeBold, 1977	x			x	x				x								x
Fernandez, Espinosa, & Dornbusch, 1975	x			x	x	x								x			
Hall, 1981		x			x					x						x	x
Hedges & Majer, 1976				x	x											x	
Jackson, 1982	x			x			x			x				x			
Jones, Burton & Davenport, 1982				x													x
Kirk, 1975	x	x		x	x			x	x	x				x		x	
Kenschaft, 1981	x	x		x	x	x	x	x	x	x	x					x	x

TABLE 2--Continued

Description of Selected Studies on Minorities and Mathematics by Influences and Outcomes

Author and Date	Influences												Outcomes			
	Parent			Student			School						Performance		Participation	
	cognitive	affective	cultural	cognitive	affective	cultural	climate	organization	resources	racial composition	personnel		achievement	progress	aspirations	persistence
Lantz & Smith, 1981	x			x	x		x	x	x	x	x				x	x
Malcom, Hall & Brown, 1976		x		x	x	x		x	x							
Marrett, 1981				x	x		x	x	x	x	x					x
Matthews, 1980	x	x		x	x			x	x	x	x				x	x
MacCorquodale, 1981				x				x		x					x	x
McNamee, Katz, & Bowman, 1981													x	x		
Nelson, 1978		x			x					x			x			
Rancifer, 1978				x		x		x		x	x				x	
Sells, 1978																x
Skypek, Lee & Cox, 1976	x			x										x	x	x
Thomas, 1981	x			x	x										x	x
Treisman, 1982				x			x	x	x	x	x		x			x
Tsang, 1976			x	x		x							x			

Cultural. Influence of language has been studied in a few instances, all with "Hispanic" populations. Cuevas and Llabre (1981), Fernandez, Espinosa, and Dornbusch (1975) and McCorquodale (1981) reported the importance of the primary language spoken at home. Cuevas (1982) raised the very good point that a child whose native language is not English will have many problems with the language constructions used ir the mathematics classroom.

Student Influence

Most of the research on minorities and mathematics has concentrated on the student. In comparison to the parental influence variables, there is a wealth of information available, the majority of which concerns the students' ascribed characteristics and affective influences.

Ascribed. There is considerable empirical evidence that race does have an effect on performance. Compared to their white counterparts, black and Hispanic students consistently scored below the national average in mathematics. Between 1972 and 1978 modest improvement was reported for 9-year-old black and Hispanic students; this favorable trend was reversed for 7 year-old-black students. Although 17 year-old Hispanic students did improve slightly in performance, they still scored appreciably below the national norm (Anick, Carpenter, & Smith, 1981).

There are very few studies in which other racial groups have been studied. In their study of minority women scientists, Malcom, Hall and Brown (1976) interviewed Native Americans. The rare studies of Asian Americans (see Hedges & Majers, 1976; Kirk, 1975; Matthews, 1981; Sells, 1978; Tsang, 1976) are often merely a discussion of descriptive statistics

of enrollment patterns. Matthews (1980) and Kirk (1975) studied Asian Americans more sensitively, although there was a gross grouping of ethnic groups. For an erudite discussion of mathematical studies of Asian Americans, see Tsang (1980).

There is evidence to suggest that there may be important sex differences in performance and participation (e.g., Matthews, 1980; Thomas, 1981). As Marrett (1981) noted, although more black females than males were in advanced courses, they were greatly outnumbered by white students of both sexes. Marrett found that, while the differences between the sexes in enrollment was not large, a larger percentage of black males than females were enrolled in lower level courses. This pattern was also found by Matthews (1980) and Rancifer (1978). However, one should not exaggerate the trends for black females. Comparable research on sex differences within racial groups other than blacks has not been conducted.

The age of the student may be a factor in differences in outcomes, particularly after age nine. There is little empirical evidence to support differences at the younger ages. In one of the few studies of pre-school children, McNamee, Katz, and Bowman (1981) looked at teacher interactions with black low income children. None of the 24 studies reviewed looked at students between kindergarten and fifth grade. We do know that after age nine significant differences are found between minority and nonminority populations, and that the differences increase as the students grow older (Jones, Burton & Davenport, 1982).

Cognitive. There is little convincing evidence that there are educationally significant racial differences in the learning of mathematics.

It has been suggested that a student's coursetaking history in mathematics may have an effect on later achievement (Fennema, 1977; Fox, 1980). That is, a student who has not enrolled in or completed a mathematics course is unlikely to score high on a test measuring the content taught in that course. In her study of 42 high schools in 36 districts, Marrett (1981) found that black students comprised over half of the sample, but they were only one-third of the enrollees in algebra II and one-fourth of the enrollees in calculus. When she looked within racial category, she found a greater concentration of black students in lower level courses. Nearly half of the black students, as compared with one-quarter of the white students, were in those courses. Moreover, black students represented a slightly smaller percentage of all mathematics enrollees than they did of the total student population. Her findings were supported by Jackson (1982) who used the High School and Beyond data base; he found that blacks were more likely to be enrolled in the lower level mathematics courses.

Affective. A number of variables have been identified as having an influence on students' decisions to enroll in mathematics, including positive attitudes toward mathematics stereotyping of mathematics, perceived utility of mathematics, and influence of significant others.

There has been some research on attitudes. Minority students have been found to like mathematics, to find it interesting, to have little mathematics anxiety, and to want to take more mathematics (Anick, Carpenter & Smith, 1981; Matthews, 1980; Nelson, 1978). These findings may seem surprising given the low achievement scores of many of these students. On the other hand, they should be encouraging because they imply that

minority youth generally have a good self-concept and may not immediately become discouraged by a poor performance.

There is conflicting evidence about whether or not minority students stereotype mathematics as a male domain (Matthews, 1980; Rancifer, 1978). Further, it has been suggested that minority students may hold racial stereotypes; that is, they may perceive mathematics to be a white domain (Hall, 1981; Kenschaft, 1981).

The perceived utility of mathematics has been studied also. Minority students are less likely to understand how mathematics will be useful to them for their future jobs or post-secondary schooling (Lantz & Smith, 1981; Matthews, 1980). They also do not seem to understand how mathematics is used everyday and tend to think of mathematics as something one only does with a pencil and paper in the classroom.

Students appear to be influenced by significant others. Teachers and counselors have strong positive effects on students' attitudes toward mathematics. Minority students have indicated that they like a teacher who will work with them, give them extra help, explain things carefully, and encourage them in their studies (Fernandez et al., 1975; Kirk, 1975; Matthews, 1980; Treisman, 1982). Early tracking of minority students into vocational or remedial programs is a continuing problem, and counselors are particularly potent influences on fifth and sixth graders when they make decisions about course selection for the junior high or middle school years (Creswell & Houston, 1980; Lantz & Smith, 1981). Many minority parents want to see their children do well in mathematics. Often, however, these parents do not know how to help their children, either with

homework or with decisions about future educational plans (e.g., Matthews, 1980).

School Influence

There are a few school related variables that have been identified as having an effect on students participation in and learning of mathematics: climate, organization, racial composition, and personnel. Much of this evidence, however, is not empirical, but qualitative.

Climate. Jackson (1982) found that school climate variables such as discipline and attendance have an effect on black students' mathematics achievement. In schools in which there were attendance or discipline problems, the black students were more likely to have lower mathematics achievement scores.

Organization. There is some evidence to suggest that the organization of the school may have an effect on black students' performance in mathematics. In those schools in which more advanced courses are being offered, a small percentage of black students have been found to be enrolled (e.g., Jackson, 1982; Marrett, 1981). Minority women scientists reported that the sequence and prerequisites for the mathematics courses as well as their placement in curriculum and the class size, affected their decisions to continue to enroll (Hall, 1981; Malcom, Hall & Brown, 1976). That is, a small class size, a placement in a more advanced track, and an early start on fulfilling the prerequisites for the more advanced classes were found to be important factors in the minority women scientists' education.

Resources. Discussions of the resources of the schools have been

included in most of the studies. These descriptions are often very brief, however, and inferences have been drawn that predominantly minority schools usually have poor facilities and few materials available. Overcrowding, and use of trailers or other temporary classroom buildings, outdated materials, lack of audio-visual and other supplemental materials are among the problems cited (Malcom, Hall & Brown, 1976; Matthews, 1980).

Racial composition. There is some evidence to suggest that the racial composition of the school may be related to other school variables as well as to student outcomes. Both Marrett (1981) and Jackson (1982) found that the larger the black student population, the more likely lower level mathematics courses will be offered and the more likely black students will be enrolled in those lower level classes. The inverse has been found to be true also. The greater the white student population of the school the more likely the school offers the more advanced mathematics courses and the more likely the white students will be enrolled in these classes. Again, through the reflections of the minority women scientists, the racial composition of the faculty seems to have an affect on student's attitudes and aspirations (Hall, 1981; Kenschaft, 1981). More often than not, the women scientists cited black teachers, couselors, or administrators who were inspirational and influential in these women's decisions to continue in a mathematics or science related career.

Personnel. Although each researcher discussed the importance of looking at school personnel, there has been little research conducted in this area. In one study of student-teacher interactions at the preschool level, that black students were observed more likely to be asked nonmath related questions (McNamee, Katz & Bowman, 1981). Matthews (1980) found

that black students preferred a mathematics teacher who would give them a second chance to pass the test, who would stay and work with them after school, and who would follow the textbook page by page.

IV. RECOMMENDATIONS

Future Research

There are a few assumptions that have been operating throughout these studies. The first assumption is that there is homogeneous performance within racial groups. It has been assumed that all students within a racial group are alike, and researchers have been less likely to consider differences in geographic location and socio-economic status, as well as other background characteristics that might affect the profile of minority students. Not only are there difficulties in using gross classifications within a racial group, there are also problems when gross classifications are used in multi-racial comparisons. Just as pooling across racial groups may obscure important within group differences, pooling across ethnic groups may mask important between group differences.

A second assumption is that since all underrepresented groups share similar goals, they can be studied similarly. For example, a very fine model has been developed to study women and mathematics (Meece, Parsons, Kaczala, Goff & Futterman, 1982). Several researchers have applied this model to studies of "minorities and mathematics." Moreover, we sometimes find the same instruments used to measure sex-related differences in mathematics also used to measure race-related differences. Given the language and cultural differences among racial groups and their effects on mathematics learning (e.g., Cuevas, 1982), it may be that these models and instruments will have to be revised or new ones developed.

A third assumption is that (a) there exists consistency in what is learned in a mathematics class, at a course-specific level; (b) this know-

ledge can be measured objectively; and (c) comparisons can then be made across schools and across the nation. Those of us who have spent time in a poor, predominantly minority school know what those students are and are not learning in mathematics. Just as the women-and-mathematics researchers have found that looking solely at test scores sheds little light on understanding why there are differences, those engaged in research on minorities and mathematics must learn also. Researchers must spend more time in the classrooms if they hope to understand the processes of learning.

In the majority of the studies reviewed, the researchers collected cross-sectional data. Apparently, there is an assumption that students do not change over time, either in achievement or in attitudes. As suggested by Bloom (1980), both achievement and attitude are alterable variables that not only can be changed but in fact do change. Although researchers are likely to take repeated measures of achievement, measures of attitude are typically collected only once. Since the primary purpose of research on minorities and mathematics is, or certainly should be, to improve learning as well as to encourage participation, it becomes imperative that there be accurate measures of changes.

Rarely have minorities been involved as researchers in studies of minorities. Those that have known problems from within can bring to the issues sensitivity that others may lack. The importance of including minority researchers is paramount. I would hope that through joint ventures, findings from the studies will more likely affect policy as it, in turn, affects the groups the researchers represent.

Based on these assumptions, a few recommendations for future research endeavors are offered.

1. Given that there are differences within racial and ethnic groups, more small case studies of minority mathematics students should be conducted.
2. Studies should include both quantitative and qualitative analyses.
3. Instruments used in the studies should be culturally validated.
4. Data should be collected at repeated intervals.
5. Minority researchers should be encouraged to engage in research on minorities and mathematics.

Prevention and Intervention

Most of the current programs are targeted for minority students in the sixth grade through the college level. There appears to be little emphasis on the early grades. With few exceptions, the studies reviewed were at junior high school level and above. It is as though we do not begin to look for ways to fill the cup until the cup is half empty. Because mathematics is a sequential subject, we need to begin to channel our energies into providing a firm foundation for minority students at the elementary level. The next years of the minority students' formal training could then be spent adding to what is already there, rather than remediating what is not.

This shift in perspective, although somewhat simplistic, has subtle but important implications for our mathematics programs. It would first necessitate a change of attitude by school personnel. And as we have seen in our efforts to provide equal access and opportunity for females to learn and to study mathematics, a positive change in the attitude of teachers,

counselors and principles can influence the outcomes of students (Fox, 1980).

There are a number of intervention programs operating throughout the country, most of them at the secondary level. For example, the National Association of Pre-College Directors (NAPD) is a network of secondary school programs which focuses on career choice and preparation in mathematics, science, and engineering.[2] The Ford Foundation (1981) has launched a major national effort "to improve minority students' performance in mathematics and to help mathematics teachers improve the quality of their instruction" (p. 9). Involved in this effort are participants from community colleges, predominantly black universities, public school districts, a New England prep school, an Ivy League college, a state university, and the American Association for the Advancement of Science. (There are several other minority programs; more information can be obtained from the Minorities and Mathematics Network).[3]

Despite the increase of special programs, few good systematic evaluation studies have been conducted. A notable exception is the Professional Development Program (PDP) Mathematics/Science Workshop at the University of California, Berkeley. Treisman (1982) has followed all of the black students since 1973 and all of the Chicano students since 1976 who enrolled in the one-year three-course calculus sequence. These data are particularly impressive because they include both the calculus grades and SAT scores, and because comparisons are made for minority and nonminority students with workshop and nonworkshop experiences. His findings are exciting and encouraging. First, they re-emphasize the need to examine more closely school structural variables. Schools can and do make a difference for minority programs, and this difference can be a positive

one. Second, Treisman found that SAT scores may not necessarily be the best predictor of success (in this case, completion of calculus sequence with average or above grades), if the student participates in a sound intervention program.

There are a number of studies and programs currently being conducted throughout the country. We can anticipate that a number of recommendations will emerge from this work. Nevertheless, there are a few recommendations that can be offered now.

1. Take advantage of the minority students' positive attitudes and natural enthusiasm for life, and encourage them to explore and discover mathematics.
2. Include examples of minority role models in the classroom. Let students meet, or at least become aware of, minority persons who are using a mathematics background on their jobs.
3. Minority students respond to hands-on activities. Be sure to include mathematics exercises that require direct and immediate application of mathematics skills.
4. Begin talking to the students about how we use mathematics everyday--at home, on our jobs, in school. Encourage these students to plan at least to complete high school and to do so in a legitimate fashion (e.g., by taking advanced level courses).
5. Plan education programs for the parents. Tell them why their children need mathematics and how parental support can make a difference.

6. Counselors, teachers, and the minority students should not assume that most minority students will enroll in a vocational education or tracked curriculum. Realize these students' potential to achieve and channel their talents constructively.

Conclusion

A number of variables have been identified as having an influence on minority students' learning of and participation in mathematics. These variables are outlined in Table 3. Few researchers could undertake a study that included all of these variables, and, indeed, that is not a recommendation. There are a few areas that should be explored more extensively. First, the influence of the school on minority students in mathematics has been overlooked and yet seems to be a rich resource for some possible answers. Studies of the school are particularly attractive because many of the intervention and prevention programs take place within the school setting. And previous research suggests that changes in structural school variables can have an important immediate impact on minority students. Second, we have little information on the importance of course-taking history on minority students' learning and participation, and this should be studied further. Finally, the influence of parents (especially mothers) needs to be investigated.

One of the greatest difficulties with the past research (and the prevention or intervention programs subsequently developed) is the emphasis on minority students who are unsuccessful in mathematics. Findings of lack of performance or of no performance are just that--findings. Any

TABLE 3

Parent, Student and School Influences that Affect
the Mathematics Performance and Participation of Minorities

Parent	Student	School
Ascribed characteristics race, sex, age	Ascribed Characteristics race, sex, age	Climate discipline, attendance
Cognitive past and present education and occupation	Cognitive past and present mathematics performance and enrollment	Organization course offerings, sequence and pre-requisites, curriculum placement, class size
Affective expectations and aspirations for child; support for mathematics performance	Affective achievement orientation, locus of control, self-concept, stereotyping, perceived utility, influence of significant others	Resources facilities, materials
Cultural communication style, primary language spoken at home	Cultural cognitive learning style, language proficiency	Personnel ascribed characteristics, professionalism, instructional methods, attitudes and perceptions, student interactions

inference drawn or conclusions made about under what circumstances minority students might perform successfully should be considered tentative at best and are probably inappropriate. Should a researcher conclude that a cognitive ability or affective attribute is lacking because of either poor performance or no performance, he or she does so unwisely.

Cole and Means (1981) recommend that, in cross-cultural research, the two causes of poor performance should be explicitly separated. Poor performance may be because the subject cannot do the task (he has not "got the process") or because the subject does not do the task (he is not "using the process"). We who are engaged in research on minorities and mathematics should first determine why the minority student performed poorly on a measure before we make conclusions and offer recommendations.

When conducting research on minorities and mathematics, it is equally important to think about participation as it is to think about performance. A number of researchers have studied why minority students do not enroll in advanced level mathematics courses, but few have focused on the factors influencing the decisions of minorities to continue their mathematics education. In those studies of performance differences, the majority of studies were generally descriptive and only confirmed what we already know: Minority students are consistently scoring below the national norms on standardized mathematics tests. Often in studies of enrollment, we find similar descriptive reports. There are a few studies in which either successful students were selected for study (e.g., Kirk, 1975; Matthews, 1980), or comparisons were made between successful and unsuccessful students (e.g., Jackson, 1982; Treisman, 1982). We need to have more studies such as these.

In the beginning of this paper, I suggested that we do not understand why there are racial discrepancies in mathematics. But we must understand. I believe that we can learn from research on minorities and mathematics. I believe that we can learn why there are differences. I believe that we can learn under what circumstances there are no differences. And I believe that we can learn how to decrease differences where they do exist. It is time to color the equation of mathematics. My challenge to you is to determine how to educate minorities in mathematics so that they might have equal access and opportunity to learn.

FOOTNOTES

[1]Following Fennema's (1977) suggestion, learning and achievement in mathematics are used interchangeably. "Both are indicated by a performance which results from the interaction of inherent and environmental variables" (p. 2). Although Fennema recognizes the limitations of using measures of performance on a mathematics test, she believes that "it is an indication of how much learning has taken place and is an efficient predictor of future success in mathematics" (p. 3). Fox (1980) uses the study of mathematics to refer "principally to enrollment in mathematics courses, particularly advanced elective courses at the high school level" (p. 12).

[2]The National Association of Pre-College Directors is located at Lawrence Hall of Science, Room 105, University of California, Berkeley, CA 94720.

[3]The Minorities and Mathematics Network is a group of researchers, practitioners and administrators who share information about research studies, special programs, and conferences. The Minorities and Mathematics Network is located at Chicago Associates for Social Research, 410 S. Michigan Avenue, Suite 525, Chicago, ILL 60605.

REFERENCES

American Institutes for Research. The Project TALENT data bank: A Handbook. Palo Alto: 1972.

Anick, C. M., Carpenter, T. M., & Smith, C. Minorities and mathematics: Results from the National Assessment of Educational Progress. Mathematics Teacher, 1981, 74, 750-568.

Bloom, B. S. The new directions in educational research: Alterable variables. Phi Delta Kappan, 1980, 61, 382-385.

Bloom, B. S. Stability and change in human characteristics. New York: Wiley and Sons, 1964.

Cole, M., & Means, B. Comparative studies of how people think: An introduction. Cambridge: Harvard University Press, 1981.

Creswell, J. L., & Houston, G. A study of sex-related differences in mathematics achievement of black, chicano, and anglo adolescents. Paper presented at the annual meeting of the American Educational Research Association, Boston, April 1980. (Available from the authors at The University of Houston, Houston, Texas.)

Cuevas, G. J. Linguistic minority students and mathematics achievement: The language factor. Paper presented at the National Council of Teachers of Mathematics Invited Core Conference: Equity In Mathematics, Reston, VA, February 20, 1982. (Available from the author at The University of Miami Lau Center, Coral Gables, FL 33124.)

Cuevas, G. J., & Llabre, M. M. The relationship of test-item readability and the difficulty of mathematical concepts and application items: a bilingual perspective. Paper presented at the American Educational

Research Association Annual Meeting, Los Angeles, California, April 1981. (Available from senior author, School of Education, University of Miami-Coral Gables.)

Erlick, A. C., & LeBold, W. K. Factors influencing the science career plans of high school students. Grant No. GY-11328. Washington, D.C.: National Science Foundation, 1975.

Erlick, A. C., & LeBold, W. K. Factors influencing the science career plans of women and minorities -- supplementary. West Lafayette, IN: Purdue Research Institute, 1977.

Fennema, E. Influences of selected cognitive, affective, and educational variables in sex-related differences in mathematics learning and studying. NIE Paper in Education and Work No. 8. Washington, D.C.: The National Institute of Education, 1977.

Fennema, E., & Sherman, J. A. Sex-related differences in mathematics achievement, spatial visualization and affective factors. American Educational Research Journal, 14, 1977, 51-72.

Fernandez, C., Espinosa, R. W., & Dornbusch, S. M. Factors perpetuating the low academic status of chicano high school students. Research and Development Memorandum No. 138. Stanford, CA: Stanford Center for Research and Development in Teaching, School of Education, 1975. (ERIC Document Reproduction Service No. ED 110 241.)

Fetters, W. National longitudinal study of the high school class of 1972: A capsule description of high school seniors. Washington, D.C.: Office of Education, 1974.

Ford Foundation. Minorities and mathematics. New York: Ford Foundation, August 1981.

Fox, L. The problem of women and mathematics. New York: Ford Foundation, March 1980.

Hall, P. Q. Problems and solutions in education, employment and personal choices of minority women in science. Washington, D.C.: American Association for the Advancement of Science, Office of Opportunities in Science, 1981.

Hedges, L. L., & Majer, K. Female and minority representation in college majors as a function of mathematics requirements. San Diego, CA: University of California, 1976. (ERIC Document Reproduction Service No. ED 007 781.)

Jackson, K. W. Achievement differences in mathematics: A search for causal explanations. Paper presented at the 6th Annual National Council of Black Studies, Chicago, March 17, 1982. (Available from the author, Dept. of Sociology, Rice University.)

Jones, L. V., Burton, N. W., & Davenport, E. C. Mathematics achievement levels of black and white youth. Chapel Hill: The L. L. Thurstone Psychometric Laboratory, 1982.

Kenschaft, P. Black women in mathematics. The American Mathematical Monthly, 1981, 88, 592-604.

Kirk, B. A. Factors affecting young women's direction toward science - technology - mathematics (NSF Grant GY-11311). Washington, D. C.: National Science Foundation, September 1975.

Lantz, A., & Smith, G. Factors influencing the decisions of nonrequired mathematics: race-related differences. Unpublished paper, The Denver Research Institute, 1981.

Malcom, S. M., Hall, P. Q., & Brown, J. W. The double bind: The price of being a minority woman in science (Report No. 76-R-3). Washington, D.C.: American Association for the Advancement of Science, 1976.

Marrett, C. B. Patterns of enrollment in high school mathematics and science. Final Report. Wisconsin Research and Development Center, 1981.

Matthews, W. Race- and sex-related differences in high school mathematics enrollment. Doctoral dissertation, The University of Chicago, 1980.

MacCorquodale, P. The effect of math and english on participation in science. Paper presented at the Western Social Science Association Meeting, San Diego, April 1981. (Available from the author at The University of Arizona.)

McNamee, G. D., Katz, L. L., & Bowman, B. T. Mathematical development in low income black preschool classrooms. Paper presented at the biennial meeting of the Society for Research in Child Development, Boston, April 1981. (Available from the authors at the Erikson Institute, Chicago.)

Meece, J. L., & Parsons, J. E., Kaczala, C. M., Goff, S. B., & Futterman, R. Sex differences in mathematics achievement: Toward a model of academic choice. Psychological Bulletin, 1982, 91, 324-348.

National Assessment of Educational Progress. Mathematical technical report: Summary volume. Denver: Education Commission of the States, 1980.

Nelson, R. W. Sex differences in mathematics attitudes and related factors among afro-american students. Doctoral dissertation, Tennessee University, Knoxville, 1978. (ERIC Reproduction Service No. WE 005 296.)

Peng, S. S., Fetters, W. B., & Kolstad, A. J. High school and beyond: A national longitudinal study for the 1980's. Washington, D. C.: National Center for Education Statistics, 1981.

Rancifer, J. L. An investigation of attitudes toward mathematics determining the election and non-election of college preparatory mathematics by secondary black and white students. Doctoral dissertation, Kansas State University, 1978.

Rothschild, S. J. S., & Lichtman, M. Factors related to white, black, and hispanic women's mathematics attainments: A descriptive study, 1980. (ERIC Document Reproduction Service No. ED 195 570.)

Sells, L. W. High school mathematics enrollment by race and sex. In The mathematics filter: A new look at an old problem, 1978. (Available from overcoming Math Anxiety, c/o S. Hamer Associates, 15 Lewis Street, Hartford, Conn.)

Skypek, D. H., Lee, E. D., & Cox, M. K. A study of factors which influence women and blacks in science career choice and stability (Grant No. GY-11321). Washington, D.C.: National Science Foundation, 1976.

Thomas, G. E. Choosing a college major in the hard and technical sciences and the professions: A causal explanation (Report No. 313). Baltimore, MD: Center for Social Organization of Schools, The Johns Hopkins University, 1981.

Treisman, P. Helping minority students to excel in university-level mathematics and science courses. Unpublished paper, The Professional Development Program at the University of California, Berkeley, 1982.

Tsang, S. L. The effects of the language factor and the cultural content factor of mathematics achievement tests on chinese and chicano students. Unpublished doctoral dissertation, Stanford University, 1976.

Tsang, S. L. A critical review of resarch on mathematics education of Chinese American students. Paper presented at a National Institute of Education sponsored meeting, Seattle, WA, April 18, 1980.

Vetters, B. M., & Babco, E. L. Professional women and minorities - A manpower data resource service. Washington, D.C.: Scientific Manpower Commission, 198[illegible].

ASSOCIATED FACULTY

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